Aug. 8, 1961 W. L. KENNEDY, SR 2,995,349

FUEL INJECTOR

Filed Jan. 22, 1960 3 Sheets-Sheet 1

FIG. 1

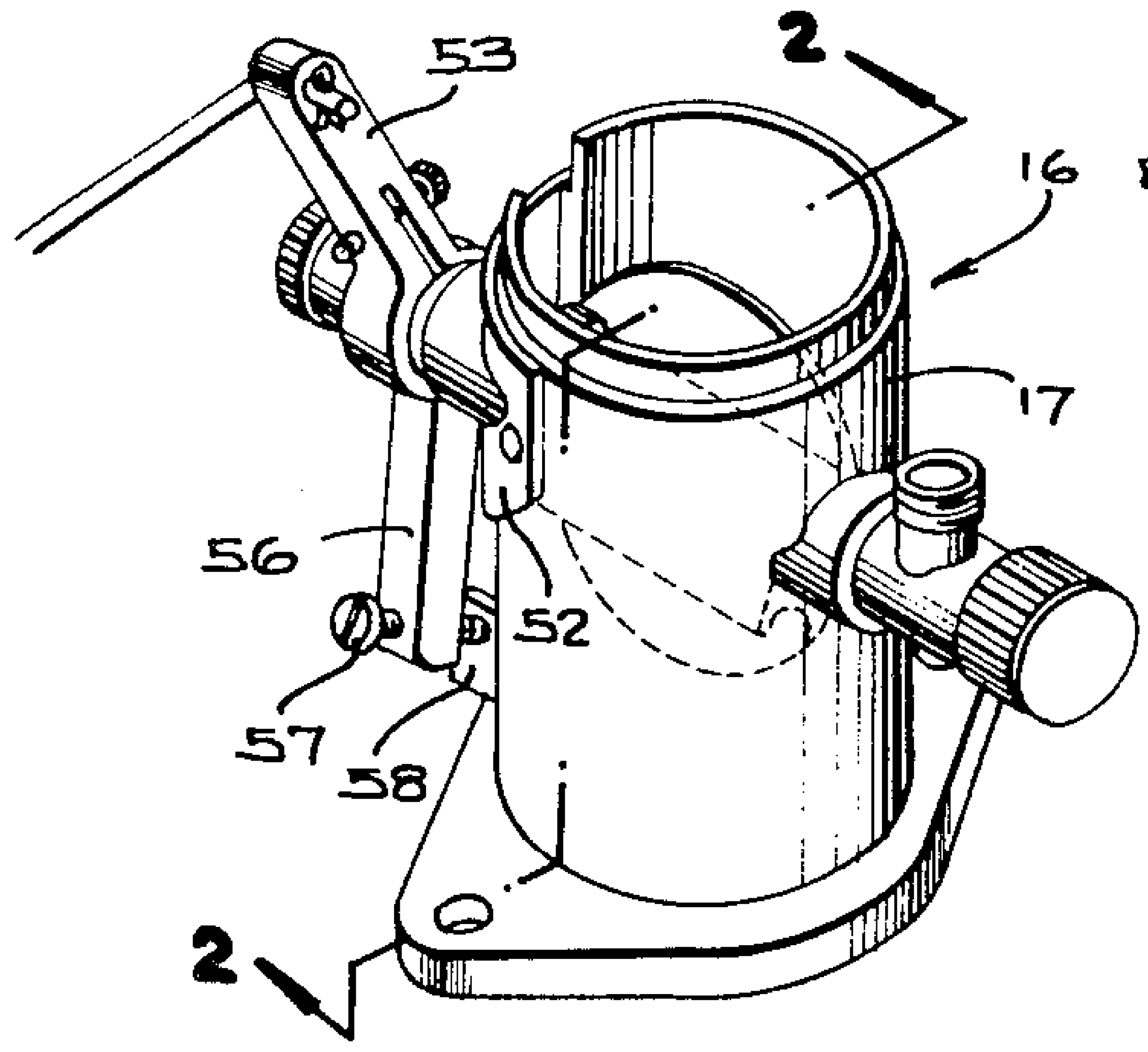

FIG. 2

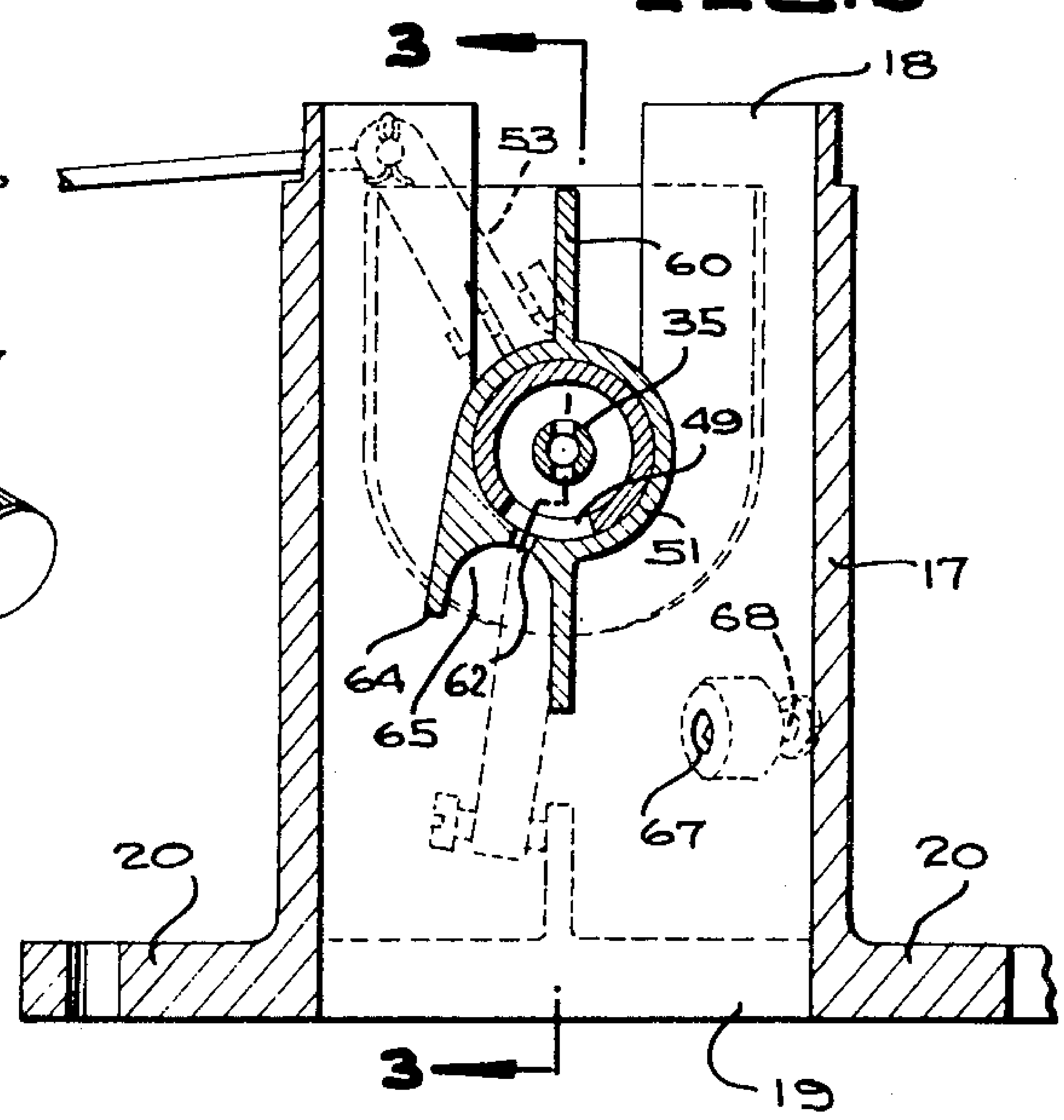

FIG. 5

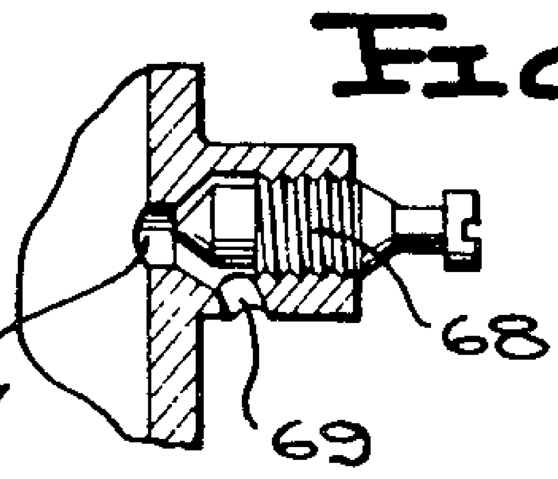

FIG. 3

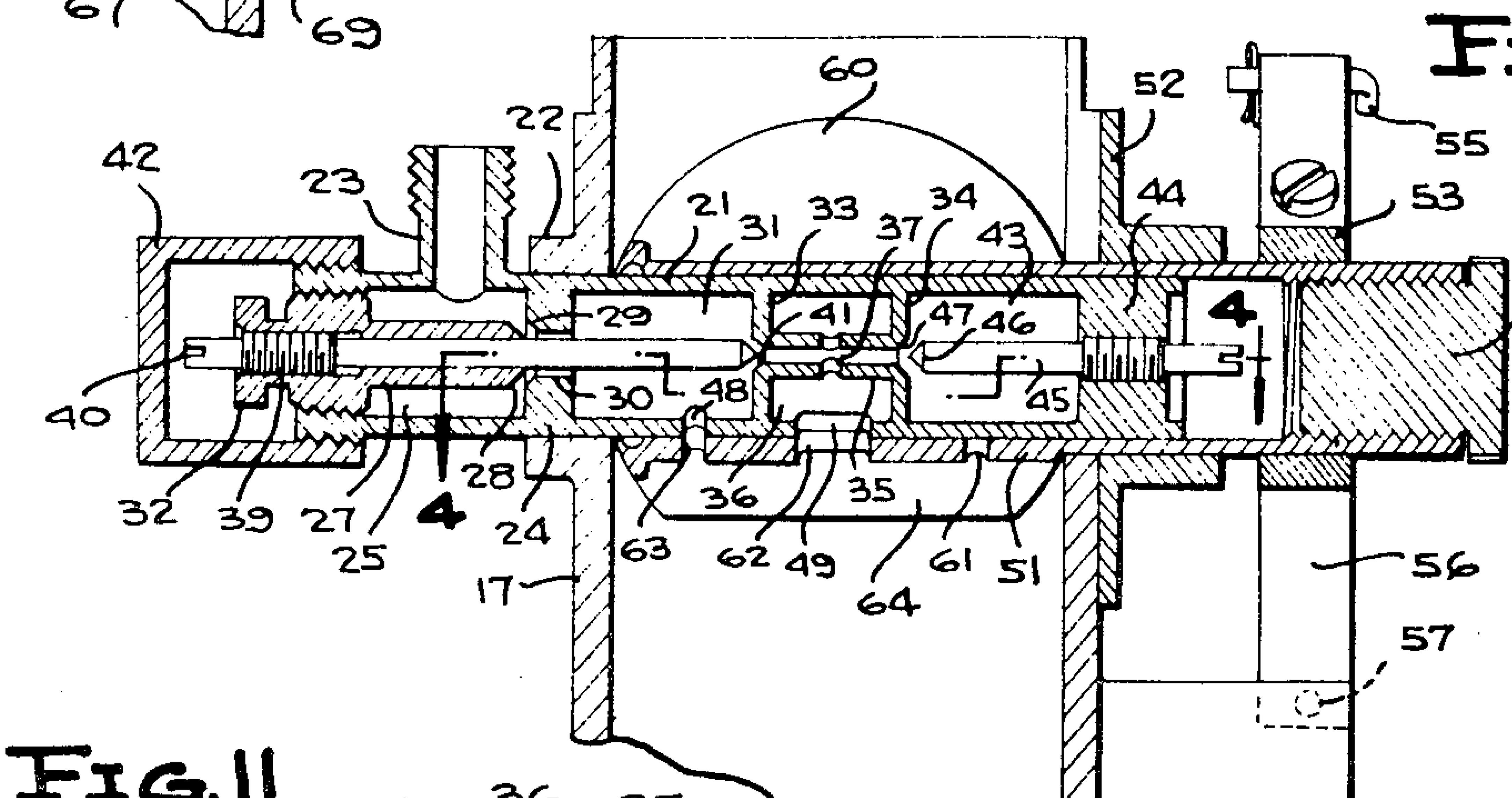

FIG. 11

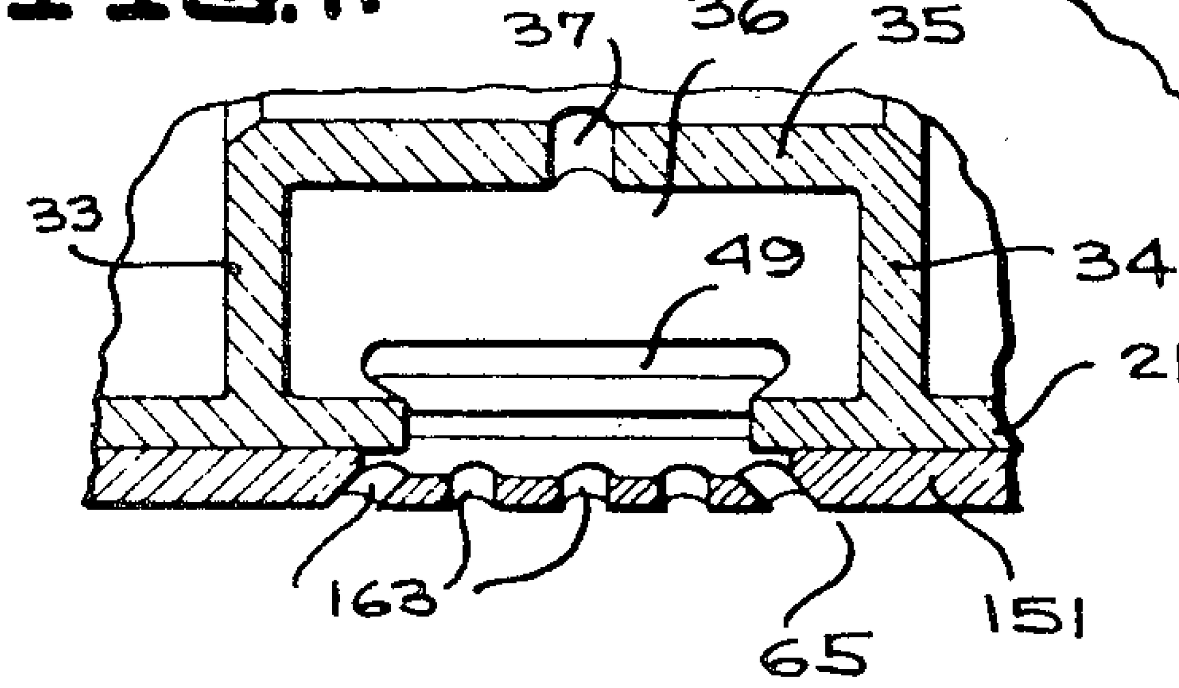

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FIG. 4

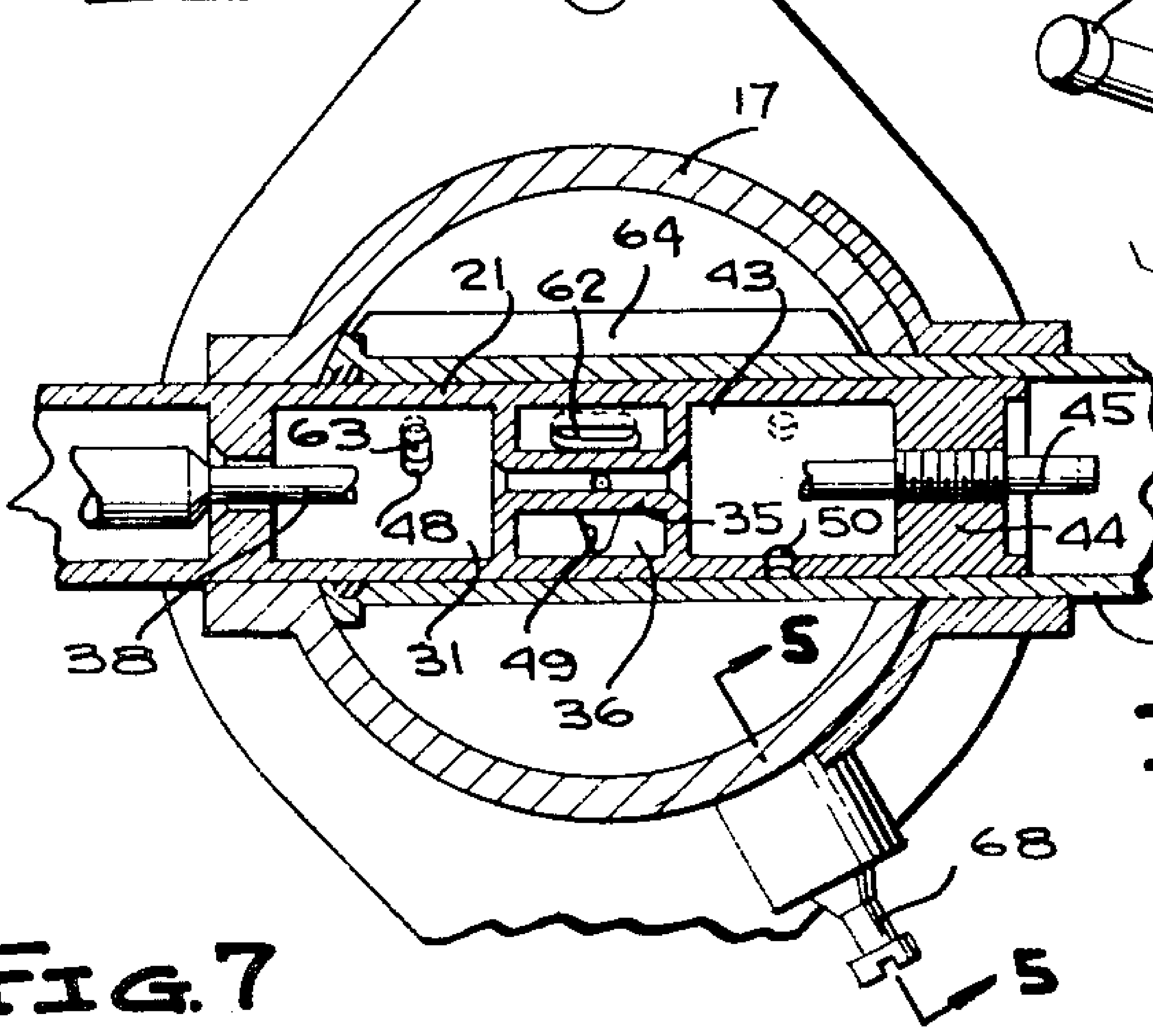

FIG. 6

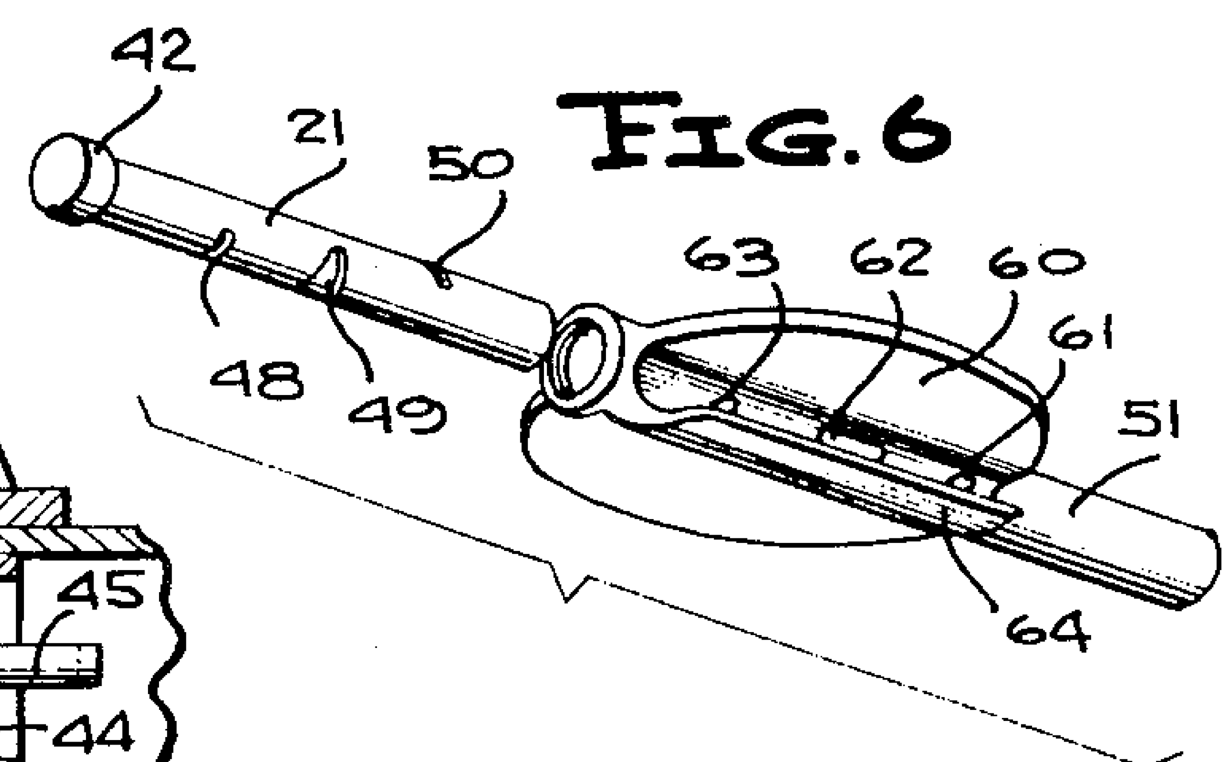

FIG. 9

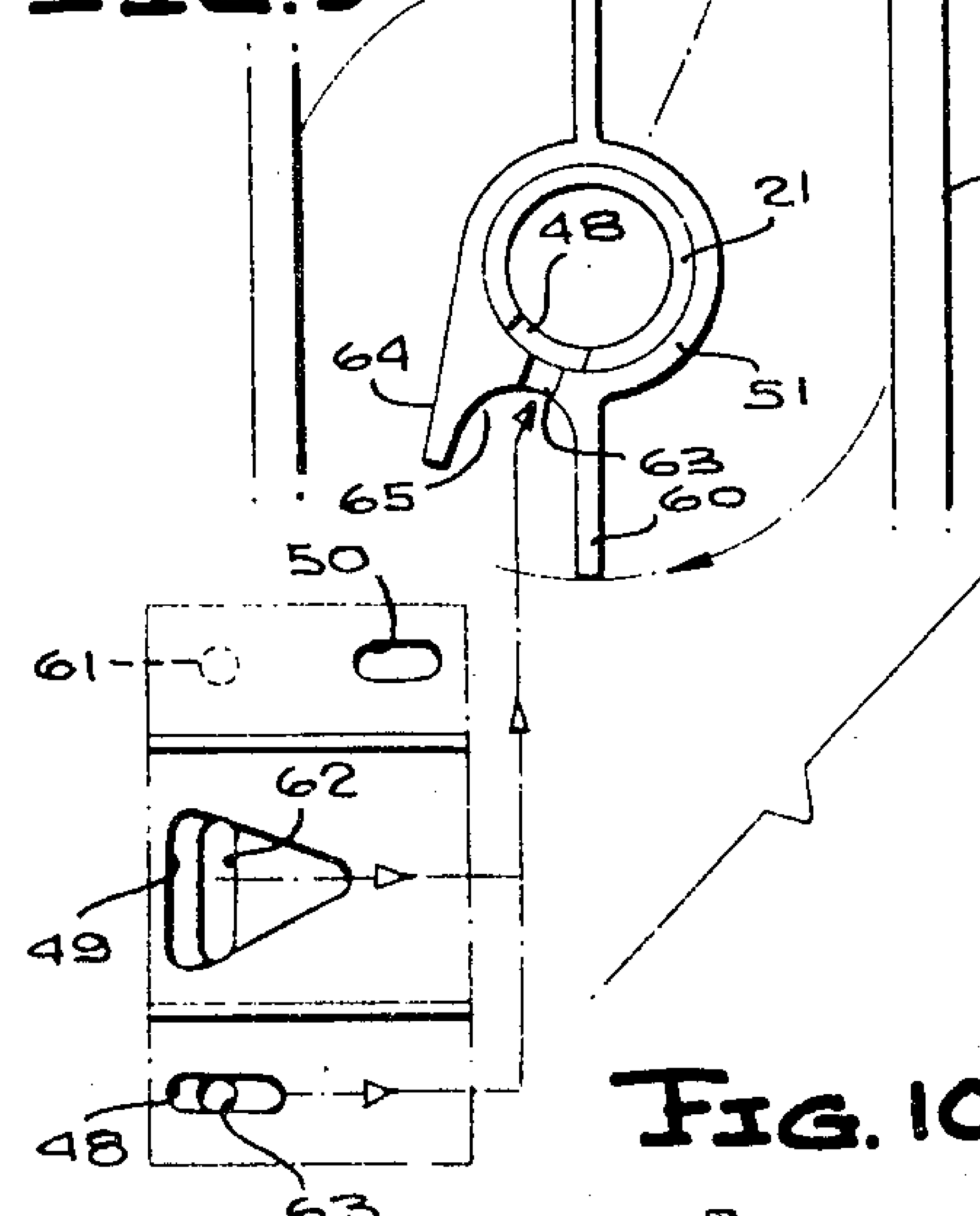

FIG. 7

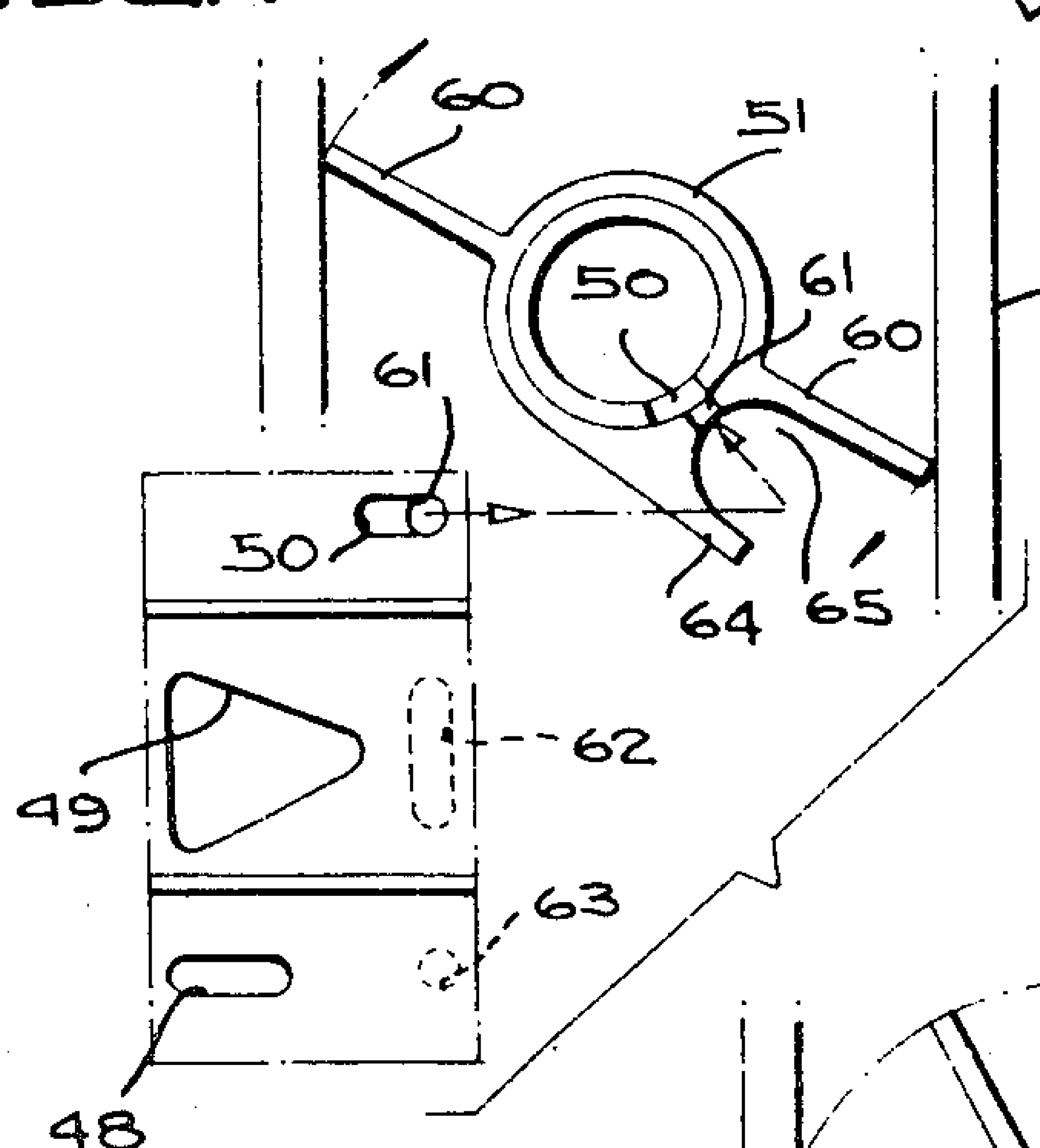

FIG. 8

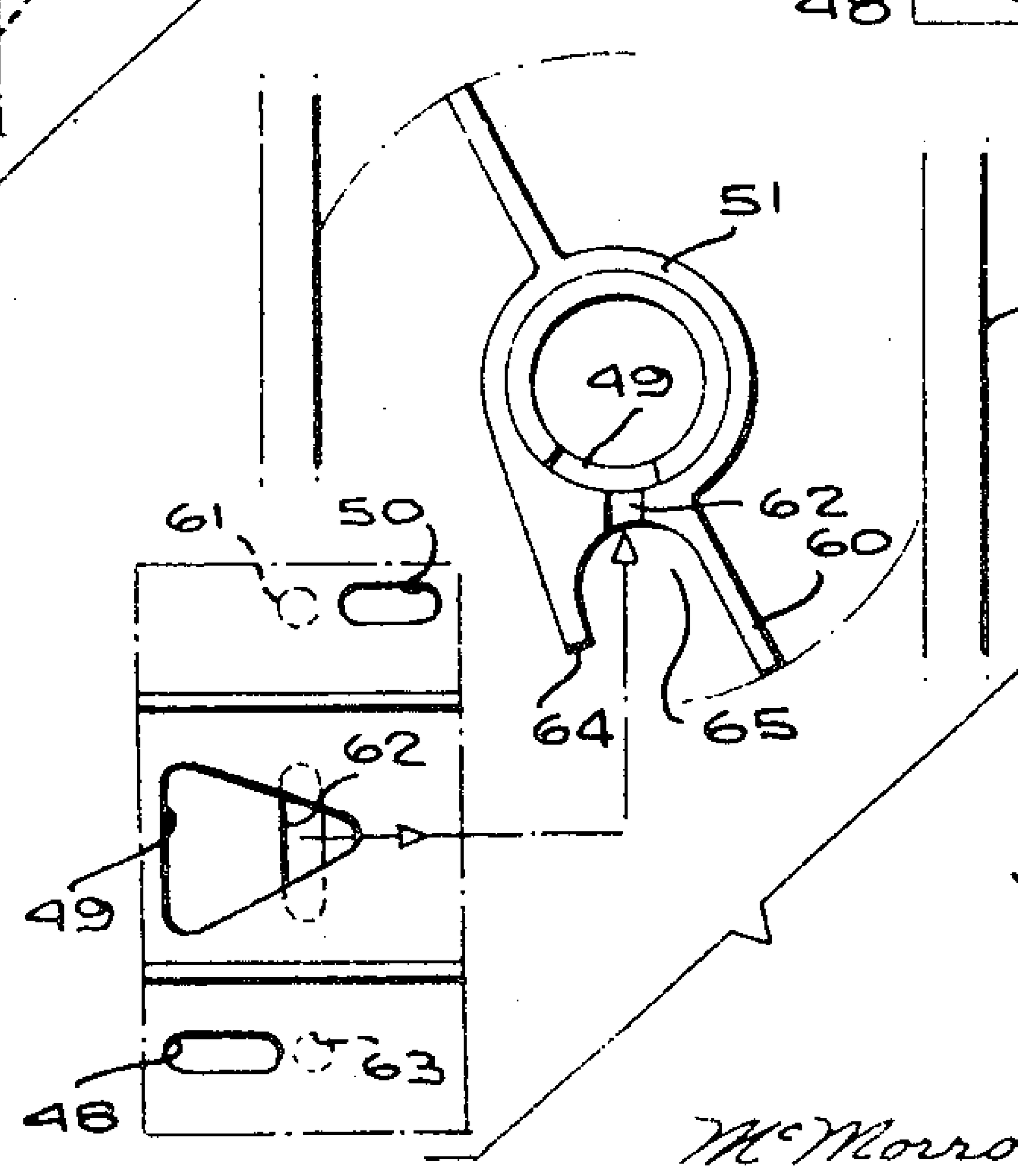

FIG. 10

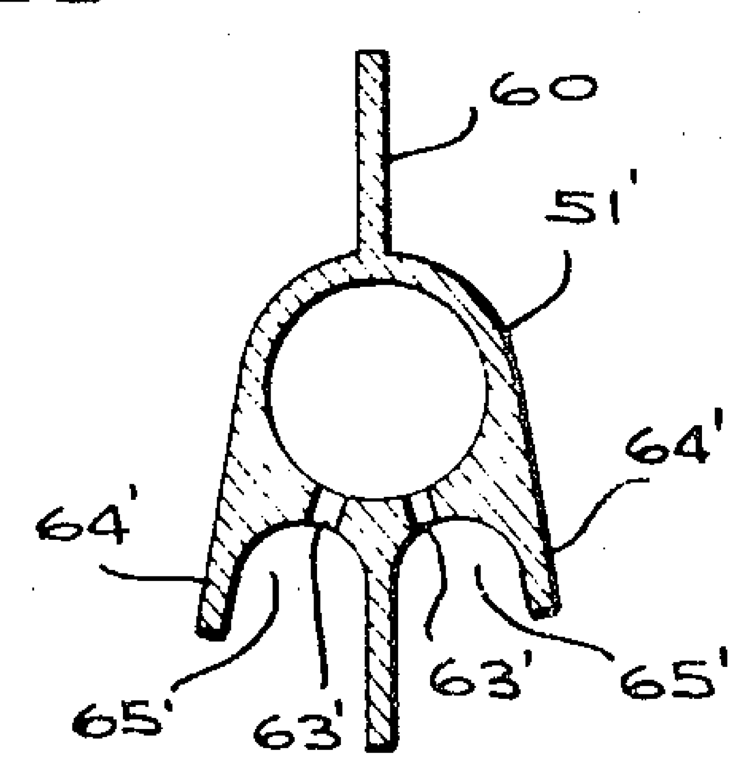

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FIG. 12

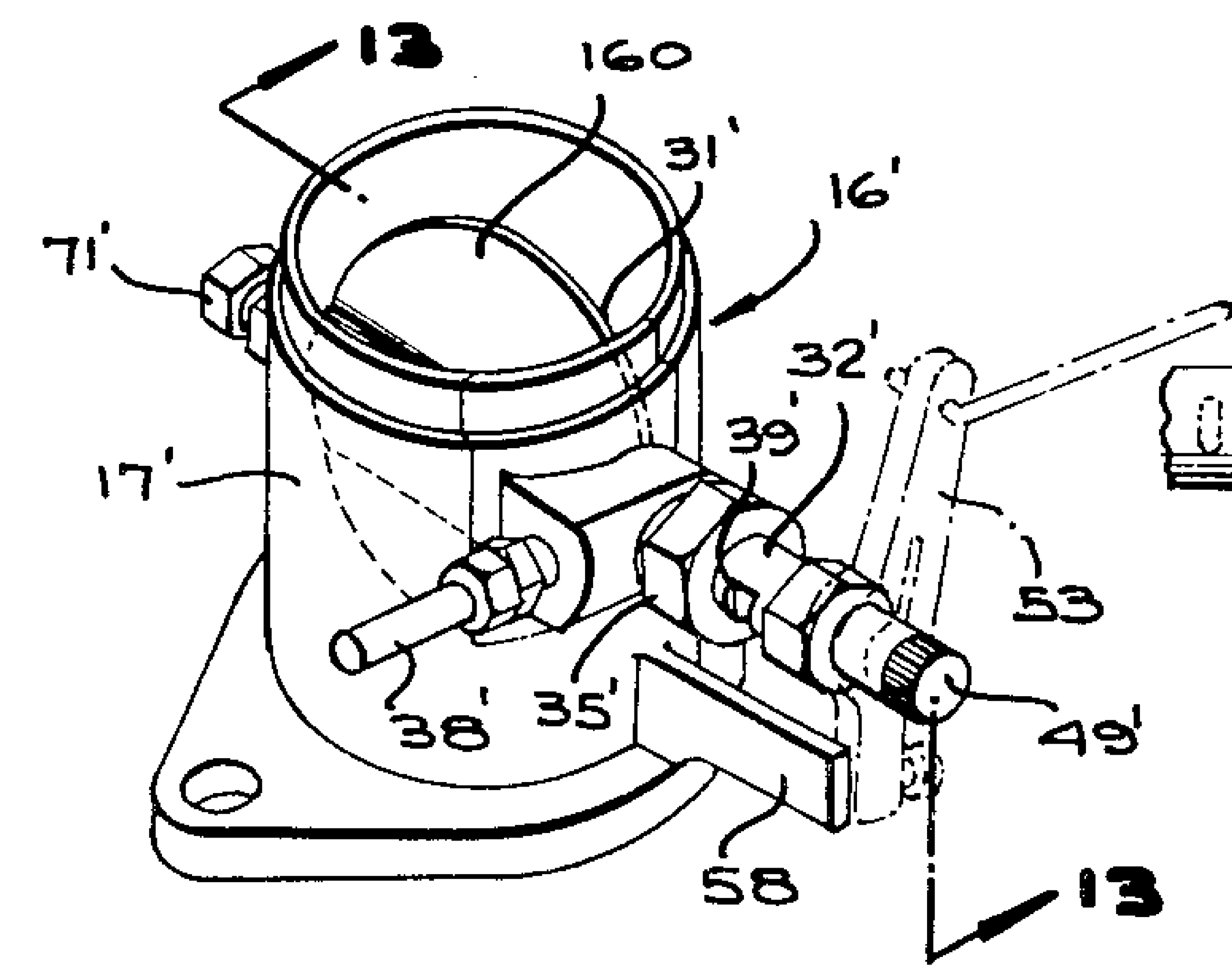


FIG. 15

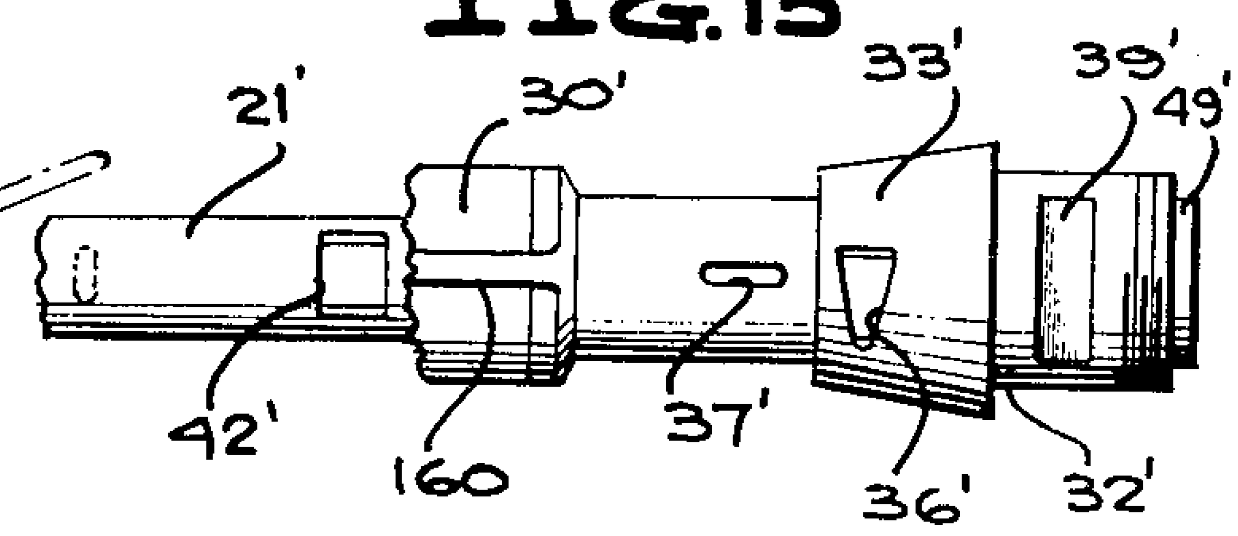


FIG. 13

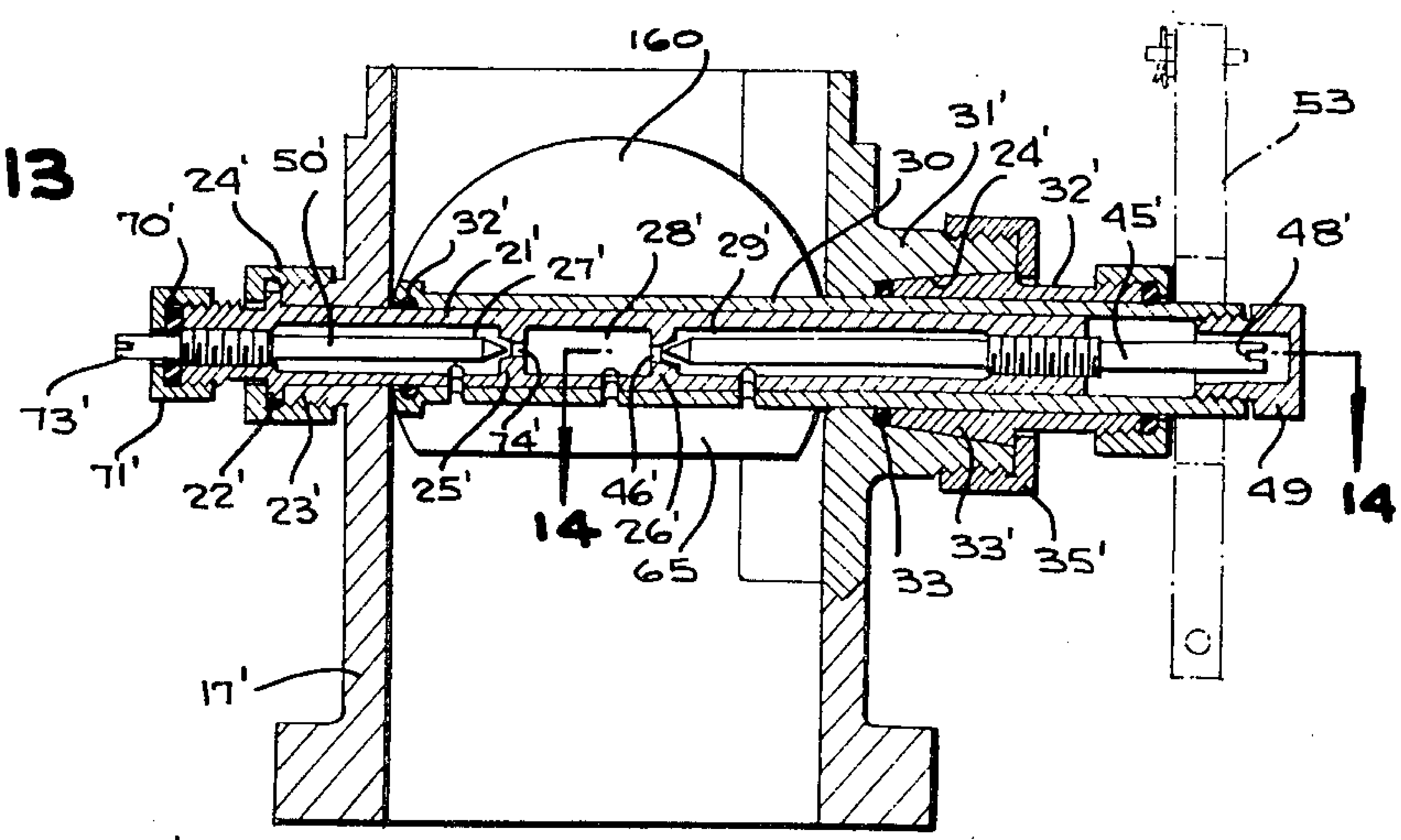
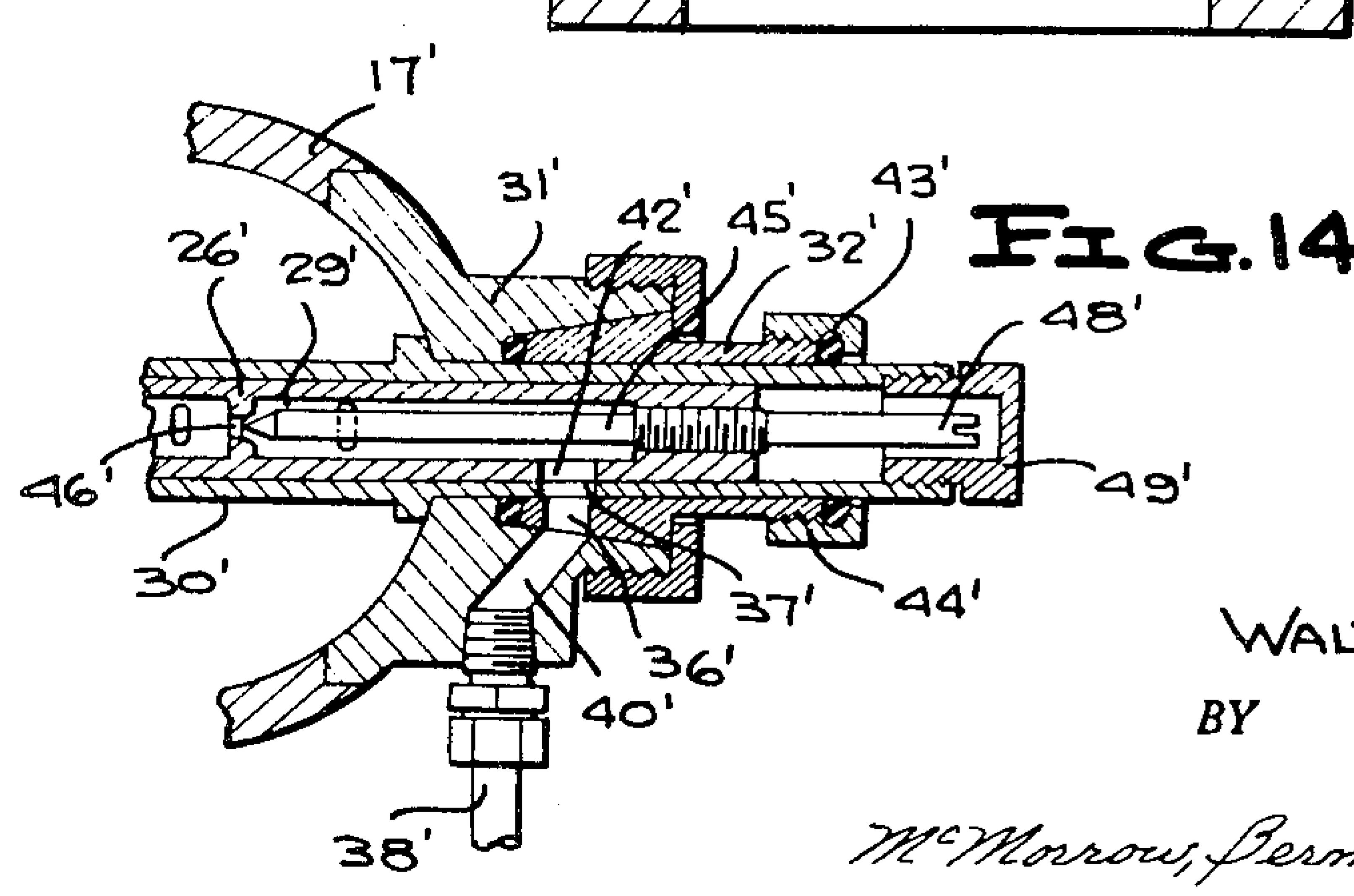


FIG. 14



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United States Patent Office

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2,995,349

FUEL INJECTOR

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Filed Jan. 22, 1960, Ser. No. 4,116
8 Claims. (Cl. 261—41)

This invention relates to a fuel injector for internal combustion engines, and more particularly to a fuel metering device adapted to be employed in place of a conventional carburetor in an internal combustion engine.

A main object of the invention is to provide a novel and improved fuel injection device for an internal combustion engine, said device being simple in construction, providing accurate metering of the fuel passing therethrough, having only one moving part, and being adaptable for use with a wide range of engines, such as those in common use on automobiles, motor trucks, marine craft, and the like.

A further object of the invention is to provide an improved fuel injector for internal combustion engines, said injector requiring relatively inexpensive parts, being easy to install, being reliable in operation, and providing substantially improved performance and fuel economy.

A still further object of the invention is to provide an improved fuel injector for internal combustion engines, said injector being durable in construction, being easy to adjust, and being adaptable for use on any four-cycle engine, and in some cases on two-cycle engines.

A still further object of the invention is to provide an improved fuel injection device for internal combustion engines which provides complete and accurate adjustable fuel metering in all ranges of operation of the associated engine, which is completely self-contained, which prevents splashing or spilling of the fuel, which employs a relatively small amount of fuel therein, which is positive in operation, and which provides immediate response.

A still further object of the invention is to provide an improved fuel injection device for an internal combustion engine which does not rely for its operation on the presence of vacuum in the intake manifold of the engine to which it is connected, which produces reduced fire hazard, which is operable in practically any position, which can be adjusted to provide either maximum fuel economy or maximum engine performance and which may be easily adjusted to provide both a desirable degree of performance and fuel economy, which is free from the possibility of icing or vapor lock, which does not require floats or float chambers, which requires no choke devices or air venturis, and which may be readily manufactured at low cost by the use of mass production methods.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

FIGURE 1 is a perspective view of an improved fuel injector constructed in accordance with the present invention.

FIGURE 2 is an enlarged vertical cross sectional view taken substantially on the line 2—2 of FIGURE 1.

FIGURE 3 is a fragmentary vertical cross sectional view taken substantially on the line 3—3 of FIGURE 2.

FIGURE 4 is a fragmentary horizontal cross sectional view taken substantially on the line 4—4 of FIGURE 3.

FIGURE 5 is a vertical cross sectional detail view taken on the line 5—5 of FIGURE 4.

FIGURE 6 is a perspective view showing the hollow shaft member and the sleeve member and butterfly valve element employed in the fuel injector of FIGURE 1, the parts being shown in separated positions.

FIGURE 7 is a diagrammatic view showing the relationship between the ports of the hollow shaft member

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and the sleeve member cooperating therewith when the parts are in positions corresponding to the idling condition of the associated engine, the relationship of the ports being shown in a developed sketch included in this figure.

FIGURE 8 is a diagrammatic illustration similar to FIGURE 7 but showing the relative positions of the parts when the injector is set to provide mid range operation of the associated engine.

FIGURE 9 is a diagrammatic illustration similar to FIGURES 7 and 8 but showing the relationship of the parts when the fuel injector device is set to provide full throttle operation.

FIGURE 10 is a transverse vertical cross sectional view taken through a modified form of sleeve member and butterfly valve element constructed in accordance with the present invention and which may be employed in the injector device of FIGURE 1.

FIGURE 11 is an enlarged fragmentary longitudinal cross sectional view taken through the portions of the hollow shaft member and cooperating sleeve member containing the mid range ports, and showing a further modification in accordance with the present invention.

FIGURE 12 is a perspective view of a further form of fuel injector device constructed in accordance with the present invention.

FIGURE 13 is an enlarged vertical cross sectional view taken substantially on the line **13—13** of FIGURE 12.

FIGURE 14 is a cross sectional view taken substantially on the line **14—14** of FIGURE 13.

FIGURE 15 is a fragmentary side elevational view of cooperating portions of the adjustable fuel supply control element, the butterfly valve sleeve and the hollow shaft portion cooperating therewith, as employed in the modified form of fuel injector device illustrated in FIGURES 12, 13 and 14.

Referring to the drawings, and more particularly to FIGURES 1 to 9, **16** generally designates a fuel injection device according to the present invention. The device **16** comprises a main fuel mixture conduit **17** which is open to atmosphere at its top end, as shown at **18**, and which is adapted to be connected at its opposite end **19** to the intake manifold of an internal combustion engine. The conduit member **17** is provided with a pair of apertured base flanges **20, 20** by means of which the conduit member **17** may be rigidly secured to the frame of an engine or to any other suitable support adjacent the engine.

Designated at **21** is a hollow shaft member which is transversely mounted in the main conduit **17** and being suitably secured in a fixed position in said main conduit, for example, by being secured to a supporting boss **22** provided in one side wall portion of the upstanding main conduit **17**, as illustrated in FIGURE 3. The hollow shaft member **21** is formed externally adjacent the supporting boss **22** with a conduit element **23** adapted to be connected to the liquid fuel supply line associated with the internal combustion engine with which the device is employed.

The hollow shaft member **21** is formed with the centrally apertured transversely extending partition wall **24** located adjacent the fuel supply conduit **23** and defining a fuel entry chamber **25** at the external end of the hollow shaft member **21**. A primary metering screw **27** is threadedly engaged in the end portion of the hollow sleeve shaft **21** and is formed with a conical end **28** which is adjustable with respect to a conical seat **29** formed in the central aperture **30** of wall **24** so that the primary rate of flow of fuel from the chamber **25** to the next successive chamber, shown at **31**, in the hollow shaft **21** is regulated by the adjustment of the screw **27**. Screw **27** is provided with an external head portion **32** which may be employed to manually rotate the screw so as to adjust the primary rate of fuel flow from chamber **25** to chamber **31**.

The hollow shaft **21** is provided with a pair of spaced intermediate partition walls **33** and **34** connected by an axially extending conduit element **35**, thus defining an annular fuel discharge space **36** between the walls **33** and **34**. Conduit element **35** is provided with a plurality of apertures **37** establishing communication between the conduit element **35** and the annular space **36**. A needle valve **38** extends axially through the screw **27** and through the aperture **30**, being threadedly engaged with the screw **27** at **39** so that it may be axially adjusted. A slotted head portion **40** is provided on the external end of the needle valve **38**, allowing said needle valve to be adjusted by means of a screw driver or similar implement. The inner end of the needle valve **38** is adjustable with respect to a valve seat **41** formed around the central opening of the wall member **33** so that by adjusting the needle valve **38**, the secondary rate of fuel metering may be adjusted, namely, the rate of flow of fuel from the space **31** to the space **36**.

A protective cap **42** is threadedly engaged on the end of the hollow shaft **21**, covering the adjustment head **32** of screw **27** and the slotted end **40** of needle valve **38**.

As shown in FIGURE 3, a fuel space **43** is defined between the wall **34** and the end wall **44** of the hollow shaft **21**. A needle valve **45** is threadedly engaged through the center of the end wall **44** and is provided with a tapered tip **46** which is adjustable with respect to a conical seat **47** formed around the central opening of the wall **34** so as to regulate the flow of liquid fuel from the conduit **35** to the space **43** in accordance with the adjustment of the metering screw **45**.

The chamber **43** is provided with a port **50**, which is in the form of a relatively short circumferentially elongated slot. The space **36** is provided with a port **49** which is of generally triangular shape and which is flared in a circumferential direction, being angularly spaced from the port **48** in the manner illustrated in FIGURES 7, 8 and 9, for a purpose presently to be described. The chamber **31** is likewise provided with a port **48**, which is in the form of a longer circumferentially elongated slot, which is located adjacent the widest end of the mid range port **49**, as shown in FIGURES 7, 8 and 9.

Designated at **51** is a sleeve member which is rotatably mounted on the hollow shaft **21** and which extends out of the housing **17** at the side thereof opposite the conduit element **23**. Sleeve member **51** is rotatably supported in a bearing bracket **52** secured to the housing member **17**, as is clearly shown in FIGURES 1 and 3. A throttle control arm **53** is secured to the outer end portion of the sleeve **51** and is connected to the accelerator pedal or other throttle control element of the associated engine, as by a link rod **55**. The member **53** is provided with an auxiliary arm element **56** through which is threadedly engaged an adjustable stop screw **57** which is in turn engageable with a fixed abutment member **58** provided on the housing **17**, thus providing an idling speed adjusting means for the throttle arm **53**.

As shown in FIGURE 3, a closure plug **59** is threadedly engaged in the end of the sleeve member **51**, the plug **59** being removable to provide access to the slotted end of the needle valve **45**, whereby said needle valve may be at times adjusted by means of a screw driver or other suitable implement.

Designated at **60** is a butterfly valve element which is integrally formed with the sleeve **51** and which is rotatable in the housing **17** to adjust the rate of atmospheric air flow into the top portion of the housing, simultaneously with the adjustment of the rate of admission of fuel into the space in the housing below the butterfly valve, as will be presently described.

Sleeve member **51** is formed with an idling port **61** which is located so as to be registrable with the arcuate port **50** communicating with the chamber **43**. Sleeve member **51** is further formed with an axially elongated slot **62** which is rotatable into registry with the different width portions of the generally triangular port **49** communicating with the space **36**. The sleeve member **51** is further formed with a port **63** which is rotatable into registry with the port **48** communicating with the chamber **31**. As shown in FIGURES 7, 8 and 9, the ports **61**, **62** and **63** are substantially longitudinally aligned, but due to the generally staggered relationship of the ports **48**, **49** and **50**, registration of the sleeve ports with the hollow shaft ports depends upon the rotated position of the sleeve member **51**.

The sleeve member **51** is formed with a longitudinally extending canopy flange **64** which is spaced from the butterfly element **60**, the ports **61**, **62** and **63** being located between the canopy flange **64** and the butterfly element **60**, as is clearly shown in FIGURES 7, 8 and 9, whereby to define a low pressure atomization space **65** between the flange **64** and the butterfly element. The channel-shaped space **65** is generally semicylindrical in shape, but has a generally outwardly flaring configuration so that the pressure therein is reduced responsive to the emission of liquid fuel from the registering ports, whereby the liquid fuel is atomized and diffused, promoting the mixture of the fuel with air passing downwardly through the housing **17** under the influence of the suction produced by the pistons of the associated internal combustion engine. Under idling conditions, namely, when the control arm **53** is in a position corresponding to the idling position of the engine, the port **50** is in registry with the port **61**, allowing a predetermined amount of fuel to pass from the space **43** into the atomization area **65**, the predetermined amount of fuel being regulated in accordance with the adjustment of the needle valve **45** in the idling chamber **43**. As will be further apparent, the idling adjustment is affected by the adjustment of the primary metering screw **27** and the needle valve **38**. However, after the necessary adjustment of the primary screw **27** and the needle valve **38** has been made, the adjustment of the idling fuel supply may be made by adjusting needle valve **45**.

Sufficient air for idling is provided by an adjustable air admission port **67** provided in the housing **17** below the butterfly valve element **60**, the port **67** being provided with a needle valve **68** which is externally adjustable and which regulates the supply of atmospheric air between an intake port **69** and the air supply port **67**, as is clearly illustrated in FIGURE 5.

As will be readily apparent, the richness of the idling mixture may be regulated by suitably adjusting the idling air supply needle valve **68**.

By rotating the sleeve member **51** in a clockwise direction from the position of FIGURE 7 to the position of FIGURE 8, the slot **62** is brought into registry with the triangular port **49**, the slot **62** first registering with the narrower portion of port **49** and gradually registering with wider portions of port **49** as clockwise rotation of sleeve member **51** continues. This provides an increasing supply of fuel to the engine. As shown in FIGURE 8, the idling port **61** is moved out of registry with respect to the port **50** under these conditions, so that mid range operation is in no way affected by the setting of the idling adjustment screw **45**. The adjustment of the mid range fuel supply thus depends on the setting of the primary metering screw **27** and the needle valve **38**, since these elements determine the maximum rate at which liquid fuel will be admitted into the conduit member **35**.

At a predetermined position of the sleeve member **51** in the mid range setting thereof, the port **48** comes into registry with the port **63**, thereafter providing full throttle operation of the engine, as shown in FIGURE 9. In this position of the sleeve member **51** the butterfly valve element **60** is positioned vertically, as shown in FIGURE 9, providing maximum air supply through the chamber **17**. Clockwise rotation of the sleeve member **51** substantially beyond the position illustrated in FIGURE 9 causes ports **63** and **62** to be moved to positions beyond registry with the ports **48** and **49**, cutting off the fuel supply.

As illustrated in FIGURE 10, the sleeve member, shown at **51'** on which the butterfly valve element **60** is mounted may be provided with a pair of canopy flanges **64'**, **64'** spaced symmetrically on opposite sides of the butterfly valve element **60** to define two atomization spaces **65'**, **65'**, and the sleeve member **51'** may be provided with ports, such as the ports **63'**, **63'** communicating with said spaces **65'**, **65'**. In accordance with the modification illustrated in FIGURE 10, the hollow shaft **21** will be formed with suitable ports located to register with the discharge ports of the sleeve member **51'** in the different positions of the butterfly valve, corresponding to the positions illustrated in FIGURES 7, 8 and 9.

In the modification illustrated in FIGURE 11, the rotary sleeve member carrying the butterfly valve element, shown at **151**, is provided with longitudinally spaced ports **163** located to register with the triangular port **49** of the hollow shaft **21** in the mid-range position of the butterfly valve. As shown in FIGURE 11, the longitudinally spaced apertures **163** are arranged to provide a downwardly flaring jet of fuel entering the atomization space immediately therebeneath, whereby to promote more effective and complete atomization of the fuel. In the arrangement of FIGURE 11, each of the orifices **163** acts as an individual opening, each nozzle opening contributing a jet of liquid fuel into the atomization space **65**, the jets being distributed over a substantial length so that they will diffuse uniformly in the atomization space **65**

Referring now to the form of the invention illustrated in FIGURES 12 to 15, the fuel injector device shown therein is designated generally at **16'** and comprises the housing **17'** in which is transversely mounted the hollow shaft member **21'**, said shaft member being provided with an abutment flange **22'** which is clamped against a supporting boss **23'** formed on housing **17'** by an annular fastening nut **24'** threadedly engaged on the boss **23'**. The hollow shaft **21'** is provided with the centrally apertured spaced intermediate partition walls **25'** and **26'** defining the chambers **27'**, **28'** and **29'**. A sleeve member **30'** is rotatably engaged on the hollow shaft **21'** and extends rotatably through a boss **31'** formed on the housing **17'** diametrically opposite the boss **23'**. Respective sealing rings **32'** and **33'** of resilient deformable material are provided between sleeve **30'** and hollow shaft **21'** and between boss **31'** and sleeve **30'**, as shown in FIGURE 13, to seal these elements. A primary metering sleeve **32'** is rotatably mounted on the sleeve **30'** and is provided with a tapering inner portion **33'** which is received within a correspondingly tapered bore **34'** formed in the boss **31'**. An annular clamping ring **35'** is threadedly engaged on the boss **31'** and clampingly engages the outer shoulder defined by the end of the tapering portion **33'**, whereby to lock the sleeve **32'** in an adjusted position. The tapering portion **33'** of sleeve **32'** is formed with a triangular port **36'** which is registrable with a longitudinal slot **37'** formed in the sleeve **30'**. The clamping ring **35'** may be employed to lock the sleeve **32'** in a position wherein the slot **37'** registers with a desired width of the generally triangular aperture **36'** of the tapered portion **33'**, to provide a desired primary rate of fuel flow into the injector.

As shown in FIGURE 14, the boss **31'** is formed with a fuel inlet passage **40'** to which is connected the fuel supply line **38'** leading from the outlet side of the fuel pump associated with the internal combustion engine on which the device is employed. The passage **40'** registers with a selected portion of the generally triangular aperture **36'** of the metering sleeve **32'**, said sleeve being adjusted to provide a rich or lean mixture, in accordance with the conditions of operation of the engine with which

the device is employed, the sleeve **32'** being locked in the adjusted position by the clamping ring **35'** as above described. A pair of flattened surface portions **39'** are provided on opposite sides of the metering sleeve **32'** to facilitate the engagement of a suitable tool, such as a wrench, or the like, with the sleeve so that it may be rotated to a desired position of adjustment.

The fixed hollow shaft **21'** is formed with a relatively large aperture **42'** which is registrable with the triangular opening **36'** in all positions of the butterfly valve element, shown at **160**, so as to allow fuel to enter the space **29'** under all conditions.

Sleeve **30'** is sealed with respect to the primary metering sleeve **35'** by the provision of a sealing ring **43'** of resilient deformable material surrounding the sleeve member **30'** and clamped in an annular cap member **44'** threadedly engaged on the outer end of metering sleeve **32'** as is clearly shown in FIGURE 14.

A needle valve **45** is threadedly engaged in the outer end portion of the sleeve member **30'** and is adjustable with respect to a valve seat provided in the central aperture **46'** of partition wall **26'**, the needle valve being provided with a slotted end **48'** which is protected by a threaded plug **49'** threadedly engaged in the outer end of sleeve member **30'**, as shown in FIGURE 14. Needle valve **45'** provides a means of adjusting the maximum rate of flow of liquid fuel from the space **29'** to the space **28'**, namely, for the maximum rate of fuel flow obtained for the mid-range operation of the engine.

A further metering needle valve **50'** is threadedly engaged in the outer end portion of the hollow shaft **21'**, being sealed at its outer portion by the provision of a resilient deformable sealing ring **70'** surrounding the outer portion of the needle valve and clamped against the end of the hollow shaft **21'** by an annular clamping ring **71** threadedly engaged on the outer end portion of said hollow shaft. The needle valve **50'** is provided with a slotted end **73'** which may be engaged by a screw driver or similar implement to adjust the needle valve. The inner end of the needle valve is adjustable with respect to a valve seat provided in the central aperture **74'** of the partition wall **25'**, whereby to adjust the maximum rate of liquid fuel flowing from the space **28'** to the space **27'**, namely, the rate of fuel flow under idling conditions of the engine.

Hollow shaft **21'** and the rotatable sleeve **30'** are provided with cooperating registrable ports to provide the varied rates of fuel supply into the atomization space **65** in the same manner as described above in connection with the form of the invention illustrated in FIGURES 1 to 9. A suitable throttle arm **53** is secured on the exposed end portion of the sleeve member **30'**, the throttle arm **53** being similar to that previously described in connection with the form of the invention shown in FIGURES 1 to 9.

As in the previously described form of the invention, liquid fuel is supplied under pressure from the fuel pump of the engine tto the fuel line **38'**, the fuel entering the space **29'** through passage **40'**, aperture **36'**, opening **37'**, and opening **42'**. Primary metering is performed by the sleeve **32'**, providing either a rich or lean mixture, as desired. The liquid fuel enters the space **28'** past the needle valve **45'**, being thus made available for mid range operation of the engine, and enters the space **27'** past the metering valve **50'**, being thus made available for idling operation of the engine.

As in the previously described form of the invention, the registering ports provided for the intermediate space **28'** and for the space **29'** are at times concurrently effective to allow fuel to be supplied to the atomization space **65** to provide full throttle operation of the engine, as previously described in connection with FIGURE 9. However, in the idling position of the butterfly valve element **160**, corresponding to the position of the butterfly valve **60** shown in FIGURE 7, only the space **27'** is placed in communication with the atomization space **65** by the registry of the cooperating ports in sleeve **30'** and hollow shaft **21'**, whereby to provide a sufficient amount of fuel to allow the engine to idle.

While certain specific embodiments of an improved fuel injection device for an internal combustion engine have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore, it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced ports formed in said hollow shaft member, longitudinally spaced ports formed in said sleeve member located to successively register with the ports of said hollow shaft member responsive to the rotation of said sleeve member, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing the first-named ports.

2. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced angularly separated ports formed in said hollow shaft member, aligned longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing the first-named ports.

3. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced, angularly separated ports formed in said hollow shaft member, said ports respectively comprising an idle port of limited circumferential length, a mid range port of relatively extended circumferential length and flaring in width, and a high range port of extended circumferential length, aligned longitudinally spaced ports formed in said sleeve member and located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, said last-named ports including a longitudinal slot whose length is sufficient to substantially register with the widest portion of said mid range port, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing the first-named ports.

4. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced ports formed in said hollow shaft member, longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, a longitudinal canopy flange on said sleeve member spaced from said butterfly valve element, said second-named ports being located between said canopy flange and said butterfly valve element, whereby the space between the flange and the valve element defines a low-pressure atomization area, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing the first-named ports.

5. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced, angularly separated ports formed in said hollow shaft member, said ports respectively comprising an idle port of limited circumferential length, a mid range port of relatively extended circumferential length and flaring in width, and a high range port of extended circumferential length, aligned longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, said last-named ports including a longitudinal slot whose length is sufficient to substantially register with the widest portion of said mid-range port, a longitudinal canopy flange on said sleeve member spaced from said buterfly valve element, said second-named ports being located between said canopy flange and said butterfly valve element, whereby the space between the flange and the valve element defines a low-pressure atomization area, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing the first-named ports.

6. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, at least three longitudinally spaced angularly separated ports formed in said hollow shaft member, aligned longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing said first-named ports.

7. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, a plurality of longitudinally spaced, angularly separated ports formed in said hollow shaft member, said ports respectively comprising an idle port of limited circumferential length, a mid range port of relatively extended circumferential length and flaring in width, and a high range port of extended circumferential length, aligned longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, said last-named ports including a longitudinal slot whose length is sufficient to substantially register with the widest portion of said mid range port, a longitudinal canopy flange on said sleeve member spaced from said butterfly valve element, said second-named ports being located between said canopy flange and said butterfly valve element, whereby the space between the flange and the valve element defines a low-pressure atomization area, and manually adjustable restriction means in the hollow shaft member between the portions thereof containing said first-named ports.

8. A fuel injection device of the character described comprising a main fuel mixture conduit open to atmosphere at one end and adapted to be connected at its other end to the intake manifold of an internal combustion engine, a hollow shaft member mounted transversely in said main conduit, means to connect said hollow shaft member to a liquid fuel supply line, a sleeve member rotatably mounted on said hollow shaft member within said main conduit, a butterfly valve element mounted on said

sleeve member within said main conduit, means to rotate said sleeve member, whereby to adjust said butterfly valve element, a plurality of longitudinally spaced, angularly separated ports formed in said hollow shaft member, said ports respectively comprising an idle port of limited circumferential length, a mid range port of relatively extended circumferential length and flaring in width, and a high range port of extended circumferential length, aligned longitudinally spaced ports formed in said sleeve member located to successively register with the ports of the hollow shaft member responsive to the rotation of said sleeve member, said last-named ports including a longitudinal slot whose length is sufficient to substantially register with the widest portion of said mid range port, said high range port being substantially longitudinally aligned with said widest portion of the mid range port, a longitudinal canopy flange on said sleeve member spaced from said butterfly valve element, said second-named ports being located between said canopy flange and said butterfly valve element, whereby the space between the flange and the valve element defines a low-pressure atomization area, manually adjustable restriction means in the hollow shaft member between the portions thereof containing said first-named ports, and further manually adjustable restriction means betwen the means to connect the hollow shaft member to the fuel supply line and the portion of the shaft member containing the high range port.

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